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INTRODUCTION

The objectives of the International conference on Applied Internet and Information Technologies are aligned with the goal of regional economic development. The conference focus is to facilitate the implementation of Internet and Information Technologies in all areas of human activities. The conference provides a forum for discussion and exchange of experiences between people from government, state agencies, universities, research institutions, and practitioners from industry. Information technologies change during time and this year AIIT conference addressed the diversity of ICT application areas and relevant research topics such as:

- Information systems
- Software engineering and applications
- Data science and big data technologies
- Business intelligence and IT support to decision-making
- Communications and computer networks
- Data and system security
- Distributed systems
- Internet of Things
- Embedded systems
- Software quality
- Software maintenance
- Computer graphics
- IT management
- E-commerce
- E-Government
- E-Education
- Internet marketing
- ICT practice and experience

Information technologies enable collaboration across the globe. This year the conference was successfully co-organized by 5 institutions from 4 countries - Serbia, North Macedonia, Russia, and Bulgaria. It has been managed in collaboration with 4 co-chairmen from Serbia, North Macedonia, and Russia.

International Conference on Applied Internet and Information Technologies (AIIT) is an annual conference that was held since 2012, based on successful results of the International Conference on Information and Communication Technologies for Small and Medium Enterprises in 2011. This year, AIIT2021 was held on October 15, 2021, in Zrenjanin, Serbia.

Due to a COVID-19 pandemics, the conference is held in virtual form, with online presentations with Google Meet, and streaming video and poster presentations available at the web site of the conference (http://www.tfzr.uns.ac.rs/aiit/). There were 40 accepted papers and 2 accepted papers in abstract with 105 authors from 14 countries (Serbia, North Macedonia, Montenegro, Bosnia and Herzegovina, Croatia, Hungary, Romania, Bulgaria, Russia, India, Malaysia, Saudi Arabia, Egypt, Canada).The papers are presented online, or in the video stream and poster sessions. Within the video presentation session, there is a presentation of IT company Crater Training Centar, Belgrade, Serbia.

The AIIT 2021 organizing committee would like to thank the authors of the papers for their contribution. All submitted papers were peer-reviewed by the members of the AIIT2021 program committee. Each submitted paper was assigned to at least two reviewers from different countries and the paper analysis was conducted as a double-blind review.

Special gratitude is addressed to many reviewers from co-organizing institutions that made a great impact on the quality of papers. The AIIT organizing committee especially appreciates the IT company's efforts in supporting the conference by its participation.

Information technologies are integrated with every human activity. IT application enhancements are encouraged by university research, business organizations, public institutions, and the IT industry. The AIIT organizing committee welcomes future presentations of work in this field at the next AIIT conference, hoping that all of us will meet again in the real conference event.

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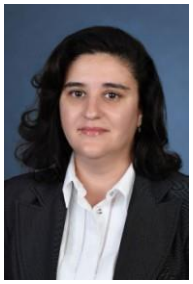

Dr. Andrijana Bocevska is an Associate Professor at the Faculty of Information and Communication Technologies, "St. Kliment Ohridski" University – Bitola, R. North Macedonia. She received her MSc and PhD degrees in Mechanical Engineering in December 2001 and October, 2012, respectively. Her research areas include: Integrated computational methods and applications, Computer integrated manufacturing, Product engineering, technology and systems. Dr. Andrijana Bocevska has published 6 books and more than 35 research articles published in international journals, conferences and congresses and she has participated in several EU and domestic funded projects. Dr. Andrijana Bocevska currently teaches subjects in: Application software, Solid modeling, Computer integrated manufacturing, Scientific visualization in virtual environments, Product Lifecycle Management. Associate Professor Andrijana Bocevska was appointed to the position of the Vice-dean for teaching and international cooperation on 01 March 2018.

Dr. Evgeny Cherkashin has graduated from Irkutsk State Technical University at 1996, at 1999 defended dissertation "Quant/2 system for automatic theorem proving" on application new logical calculus for control technical systems. After that, he mostly deals with application first-order logical inference systems for model identification algorithm synthesis, software model transformations. Most of the scientific activity is carried on in Institute for Systems Dynamics and Control theory of Siberian Branch of Russian Academy of science, at Laboratory of Complex information systems. E.Cherkashin instructs students of two Irkutsk universities programming, software design, real-time system engineering and artificial intelligence. He is author more of 160 scientific papers.

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Application of the Blockchain Technology in Medicine and Healthcare

Panche Tashevski, Blagoj Ristevski, Snezana Savoska, Ilija Jolevski, Mimoza Mijoska
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Abstract – Applications in the field of medicine and healthcare would include electronic health records, health insurance, biomedical research, drug supply and procurement, and medical education. One of the requirements for health and medicine is interoperability, which represents the ability to exchange data or information accurately, efficiently and consistently. There are currently problems with the amount and exchange of data in healthcare. The potential for blockchain in healthcare is to solve the challenges connected with the security, privacy, sharing and storage of data. A proposed model in this paper describes a new procedure of design and implementation on a decentralized platform for managing data with blockchain for providing more secure, transparent and significant medical assistance for patients and providers of healthcare globally.

Keywords: blockchain, data decentralization, electronic health data, e-health.

I. INTRODUCTION

The first blockchain was created by the unknown persons behind the online cash currency bitcoin, under the pseudonym of Satoshi Nakamoto in 2008. He described: "A purely peer-to-peer version of electronic cash would allow online payments to be sent directly from one party to another without going through a financial institution". The word blockchain is a combination of two words, the first is "block" and the second is "chain", and this is a combination of more blocks in a chain equal to the blockchain. The first block was developed at the beginning of 2009, and that is the beginning of the new revolution in informational technologies. Decentralization as the main feature on blockchain was introduced in Web 3.0, where the "Dapp" Application was decentralized and they will be everywhere [2].

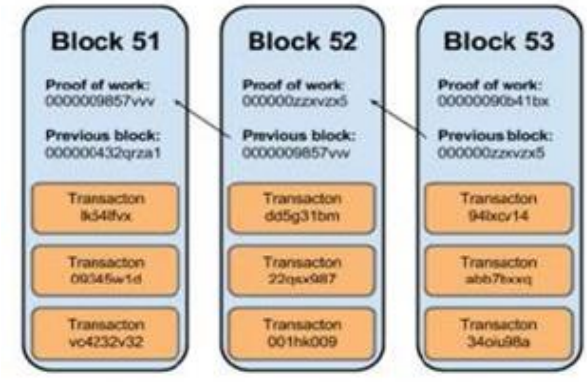

Figure 1. Blockchain blocks [3].

Blockchain is registered for all transactions because every system keeps a record of the transaction and is stored as a database. Important for blockchain systems is how the transaction information is sent and stored. At bitcoin transactions the data have stored in blocks, this is shown in Fig. 1. Cryptography is an integral part of the inner workings of blockchain technology, more precisely the hash function in such a way where is impossible to change content on one block without a content change for all of the blocks who follow him. This is an extremely important feature of blockchain's, as it ensures the immutability of the data entered into the block.

Bitcoin is a decentralized system which means that there are no central servers. All users are connected in a peer-to-peer network and every user presents one node on this network is shown in Fig.2. Because a peer-to-peer is that every user makes a direct connection with several other users, it means that the user is indirectly connected to all other users. Information was travelling through a peer-to-peer network to each of its participants with sent a message only to users who are connected directly. It means each of the users when sent a message to users who are directly connected, the message passes to all of the participants in the network, but only those users who are directly connected to the sender have an overview.

Figure 2. A peer-to-peer network

The Byzantine generals' problem is one of the most well-known and classic problems faced by decentralized networks. Solving this problem was one of the key developments in the creation of Bitcoin and, by extension, all other cryptocurrencies. Some of the nodes in the network have a complete blockchain. Because the nodes constantly communicate with each other, they always check that their copy of the block matched to block on the other nodes. If the block doesn't match with others, then the node updates automatically its version for agreement with the rest of the nodes in the network. This is a kind of database that is connected to thousands of

computers that are constantly updated in real-time. Every bitcoin user has a private key, public key and bitcoin address.

The public key has been created from the private key, but on the way that is impossible to make a reverse process that is to make a private key from the public key. Then, a public key is created, and a bitcoin address that's not in danger of abuse does therefore not need to hide. From the other side, very important is a private key to be kept well, because it is needed upon signing transactions with bitcoin address with key what is connected. For example, if the bitcoin address is signing as banking number of user account and private key has signed pin of the user who is using to confirm payment from that account.

There is one very important difference around this functionality: If the user lost his pin who confirm a transaction from his banking account, then the bank will create a new pin, but if the user loses his private key with it loses his bitcoin address forever. These bitcoins exist, but no one can access them without a private key.

When the user will want to send his bitcoins to another user, he must enter the recipient bitcoin address, the amount he wants to send and sign the transaction with his private key. Then, the information for that transaction is sent to participants with whom a user connects directly with a peer-to-peer network, so that will be forwarded until it reaches the recipient. Bitcoin transactions were forwarded only by a mediator. Every node in a bitcoin network is a mediator, which checks the transaction and forwarded it when doesn't reach all the nodes. Every time a transaction occurs it has to be approved by the nodes, each of them checks its validity. Once every node has checked a transaction there is a sort of electronic vote, as some nodes may think the transaction is valid and others think it is a fraud. The nodes referred to above are computers. Each node has a copy of the digital ledger or blockchain. Each node checks the validity of each transaction. If a majority of nodes say that a transaction is valid then it is written into a block.

The process of mining or creating blocks is:

The users take verified transactions from the pools to create a new block. The number of transactions that will be potentially added in the block, check the way of the payment and other criteria are decided by the user. The users created Merkle Tree from the transaction in the first step, until they take root in Merkle. Merkle tree, also known as a hash tree, is a data structure used for data verification and synchronization. It is a tree data structure where each non-leaf node is a hash of its child nodes. All the leaf nodes are at the same depth and are as far left as possible. It maintains data integrity and uses hash functions for this purpose [12]. The structure of the Merkle tree and Merkle root is shown in Fig. 3 [5].

If a parameter in the transaction changes, his hash will change, that way root hash will not correspond to the written root in the block. Miners hash the block header with the corresponding hash function.

The rest of the paper is organized as follows. blockchain technology in healthcare and medicine is explained in Section II, while electronic healthcare records (EHR) is explained in the third Section. Internet on medical things (IoMT) is described in the subsequent Section. The process for issuing and filling out medical prescriptions is explained in Section V, while the sharing laboratory test/ data of result is explained in Section VI. Smart contracts based on Ethereum for clinical trials are described in the seventh Section. Data flow for compensation in healthcare is explained in Section VIII. The proposed model of the blockchain system in medicine and healthcare is highlighted in the subsequent Section. The last Section gives concluding remarks.

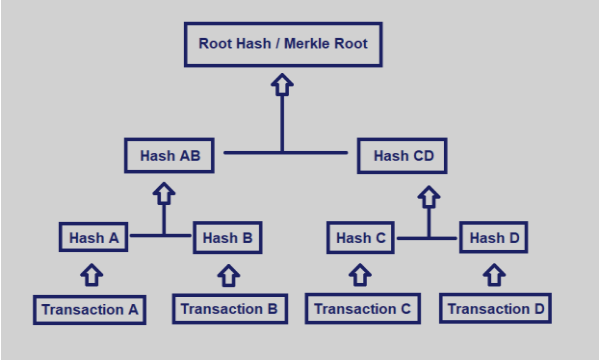

Figure 3. Merkle Tree [5].

II. BLOCKCHAIN TECHNOLOGY IN HEALTHCARE AND MEDICINE

The potential for blockchain in healthcare is to solve the challenges connected with the security, privacy, sharing and storage of data.

One of the requirements for health and medicine in the industry is interoperability, which represents the ability to exchange data or information accurately, efficiently and consistently. Interoperability in healthcare has a purpose to facilitate the exchange of information connected with healthcare, between providers on healthcare services and patients.

In healthcare, the blockchain has a positive impact on the result of the healthcare on the companies and interesting parties to optimize the business process to improve the patient result, management with data of the patient, lower costs and better use of records connected with healthcare protection. The ability to share information for medical healthcare without risk of privacy and security of records of endangerment on users and patients is one of the primary steps for improvement in the quality of healthcare service for patients and users.

III. ELECTRONIC HEALTHCARE RECORD (EHR)

Traditional medical files known as PHR (Personal Healthcare Records) are written on paper. Information

technologies allow the introduction of electronic healthcare records known as EHR [6].

EHR system is developed with help of blockchain technology, where data will be able shared securely or kept in the frame of the institutions. EHR content complete data of the patients like the history of examinations, tests, results, diseases, drugs and prevention, etc. Electronic access to health records allows the doctor to get a significant improvement of quality treatment on patients [7].

EHR allows better measures to treat the disease, improvement of healthcare delivery and increased level of preventive care to patients.

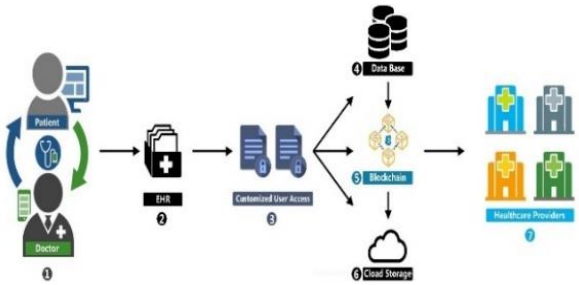

Figure 4. EHR in Blockchain medical system [8].

The primary data was generating of interaction between the patient and his doctor and specialist. This data consists of medical history, current problems and other physiologic information. EHR was created for every patient by using primary data collected in the first step, as shown in Fig.4. Other medical information that is generated by medical care, medical picture, drugs and history are input in the EHR.

Individual patients can access their EHR, while a customed control is given only on the institution for which the patient was referred [12]. Institutions that want to access information must ask for the permission of the patient, and a patient is a person who decided to whom give access control to his data. These three steps were a part of the core of all processes, including database, blockchain and storage data in the cloud. Healthcare providers, such as ad hoc clinics, hospitals are the end-users who gain access to secure data delivery and are authorized by the owner or the patient.

IV. Internet of Medical Thing (IoMT)

In the IoMT area, the patient is a source of all data. Medical IoT devices are normally connected or in the distance where they follow patients through generating a big data volume. The created data are stored on a block or they stored in the cloud. Artificial Intelligence will help the blockchain to make intelligent virtual agents, which will be able to automatically create new records [10].

In the case of sensitive medical data, where the priority was security, a decentralized system will help with blockchain to reach better security. Lenders for health care are the last users who want access to health and secure delivery. The blockchain application for the Internet of Medical Things is shown in Fig.5.

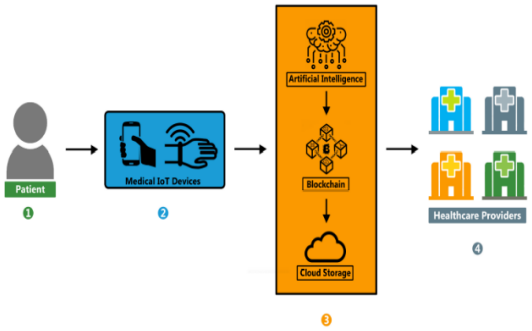

Figure 5. Blockchain for the Internet of Medical Things [8].

V. Process for Issuing and Filling Out Medical Prescriptions

The process of medical prescription management was going to eliminate a long time process for waiting, remove an element for fraud of system and reduce the mistake made on the side of misinterpretations by doctors.

The doctor prescribes for the patient and he enters a patient's data in health evidence with a smart contract.

The pharmacy through a smart contract on the Ethereum blockchain access the prescription with permission given by the primary doctor and patient.

After access to the prescription, the pharmacy issues medicine and the way of usage sending by a smart contract on Ethereum blockchain [9].

VI. Sharing Laboratory Test/ Data of Result

The patient visits a laboratory for blood testing, and after the data processing and examination, the laboratory shares results and put them into the patient health record. Patients through the Ethereum blockchain will get a notification where the processed result of the test is available.

The patient permits to share a piece of information on a blockchain. When a patient will allow to share a medical record of the blockchain medical system, the result will be available in the medical system.

Laboratory through the Ethereum blockchain healthcare system will access patient information for his working place where they commit payment for this service.

VII. Smart Contract Based on the Ethereum for Clinic Trials

To enable users to execute smart contracts connected with clinics trials on the Ethereum network was resulting in more secure drugs.

In this process, more metadata, including registration on protocols, previous set details, diaries for screening and writing through a smart contract are used.

Pharmaceutical companies' metadata will be stored in the Ethereum blockchain for the identification of potential patients for inclusion in the clinical trials.

The organization was sending a message to selected patients, including applications for reading and access to their medical records, including any relevant results of laboratory studies.

If the patient is allowed access to the account, the pharmaceutical company will be processed through a smart contract. The patients, meanwhile, besides compensations for participation in trials, will be accessible to the new treatment.

VIII. DATA FLOW FOR COMPENSATION IN HEALTHCARE

The doctors will quickly resume patient care instead to maintain the treatment of their patients while they are waiting for an answer from the payer.

The companies from healthcare insurance are sharing their policies through the smart contracts on Ethereum blockchain technology.

The supplier submits to blockchain application for previously permission for meeting on specialist, treatment or recipe.

Smart contract for a medical decision-maker of the payer determines automatic payment approves with using patient medical information. The patient and all of the laboratories, pharmacy and specialists on which patient delegated access will be checked insurance with having authorization in real-time.

IX. PROPOSED MODEL OF BLOCKCHAIN SYSTEM IN MEDICINE AND HEALTHCARE

The users such as doctors, nurses through applications connected with blockchain will access data when they have a patient code. The user to get a code of data of the patient has to check the PHR application and access with patient code which is required to input to required records.

The medical user has received code and inputs him in the blockchain system where he was performing a check in the medical database in which they are enrolled patient records. The received data with blockchain technology are decrypted with a code entered in medical user who gets them EHR records of the patient, but a user can check patient's insurance. When a medical user will finish the task with a patient, he/she writes a result through a blockchain in the medical database or on the cloud storage.

During the payment, the medical users and hospitals where they are employed through the blockchain access to data in the healthcare fund, and the funds are distributed appropriately. If the patient has different insurance, it will calculate whether the cost will be covered by the healthcare fund, and/or by the company where the patient worked.

Access to medical data may have and Pharmacy when patients are depending on medicines. Also, patients who have IoT devices connected through an application where entering data their code through their devices and will gain access to the data.

The Farmacy companies through blockchain technologies will receive additional information's for finding new pharmacy solutions, but also to improve the old ones through organized reports.

Governmental and other institutions can access medicine data through blockchain technology through execution on different statistic procedures that are performed during check-in the healthcare system in one same country. The proposed blockchain system in Medicine and Healthcare is shown in Fig.6.

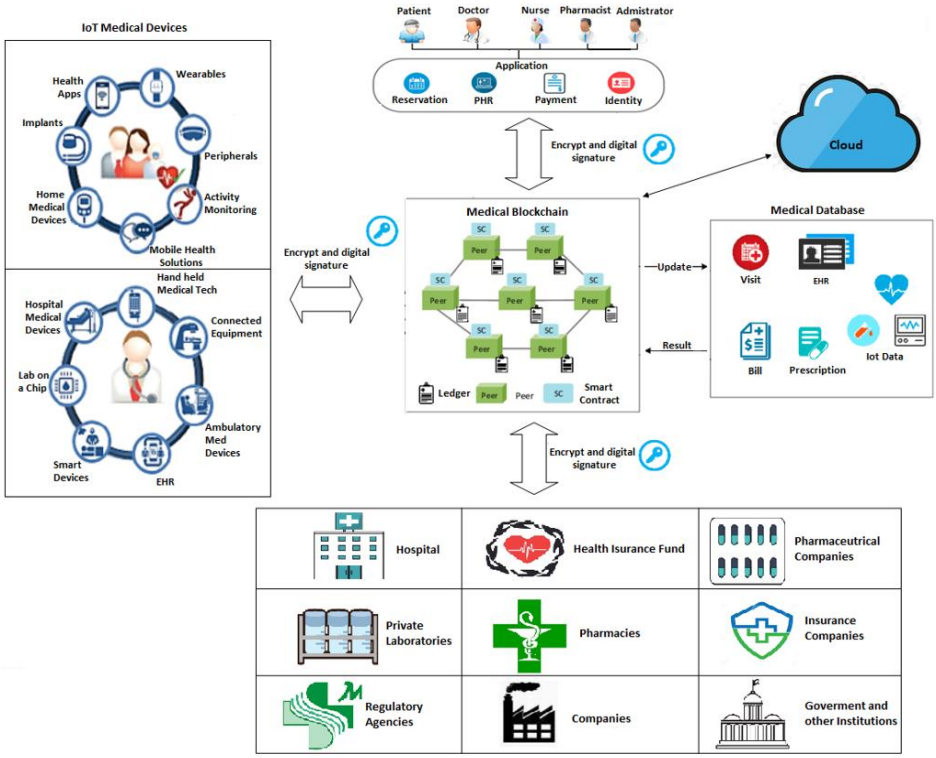

Figure 6. Proposed Blockchain System in Medicine and Healthcare.

X. CONCLUSION

Blockchain has the potential to solve many problems in the healthcare sector today. Through this technology, new solutions in healthcare and medicine can be provided. This new model uses new dynamics through different stakeholders in medicine, such as patients and providers of services.

A proposed model in this paper describes a new procedure of design and implementation on a decentralized platform for managing data with blockchain for providing more secure, transparent and significant medical assistance for patients and providers of healthcare globally and in the hospital. Using a blockchain in this model improves the process of healthcare for the patient.

Blockchain can help in many ways through reduced transaction costs by using smart contract which is embedded for the general purpose of simplifying procedures, reducing administrative burdens and removing intermediaries.

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